It is clear that the "at any point in time" requirement cannot be satisfied by *any* pulsed device that employs some quiescent periods. Moreover, a smooth power spectral density is likewise not possible at any point in time, but rather requires a finite observation time period. Thus, to determine compliance with the UWB minimum bandwidth requirement, two parameters must be specified:

(1) the spectral smoothness or power spectral density that is required; and
(2) the finite observation time allowed to achieve spectral smoothness.

The main difference between the pure pulsed devices and the Siemens pulsed FH devices relates to how the spectral smoothness is achieved. Pure pulsed devices dither their line spectrum with PPM (in the time domain), whereas pulsed FH systems achieve the spectral smoothness by frequency shifts (in the frequency domain). The Fourier Transformation establishes the relationship between the dithering and frequency hopping principles, which, in theory, should be equivalent due to the dualism theorem.

---

spectral lines) that are more than 500 MHz apart and less than 10 dB below the maximum power level. This would be one possible scenario under which the "at any point in time" criterion could be satisfied, because the device would be emitting at the two "edge" frequencies at all times (if not pulsed) and more than 500 MHz apart. However, Siemens VDO does not believe that this scenario was intended by the Commission in drafting its rules (see, *e.g.*, Technical Annex at slide 13).

III. SIEMENS VDO'S PROPOSALS WOULD PERMIT THE ACCURATE MEASUREMENT OF PEAK AND AVERAGE POWER LEVELS

Siemens VDO supports the Commission's proposal to apply the existing UWB emission limits to the Siemens VDO pulsed FH vehicular radar, albeit with different measurement techniques.[24]

A. Peak Power Measurements

With regard to taking peak measurements, there is no difference between spectrum analyzer peak measurements taken with the frequency hopping active and such measurements taken with the frequency hopping stopped. In addition to the absolute peak power of the unmodulated carrier, the main factors that influence peak readings are the pulse duration (which influences the PDCF value) and the PRF (which determines the number of spectral lines that fall within the spectrum analyzer RBW). If the frequency hopping is stopped, the maximum peak power reading occurs at the carrier frequency. Depending on the RBW/PRF ratio and the pulse width, measurements may be taken either of a sinc-shaped peak power envelop or of the peak power of each single line spectra (especially for high PRF). To detect the maximum peak value over the entire occupied bandwidth, frequency hopping must be either active or, if in stopped mode, the carrier frequency must be stepped through the entire occupied bandwidth manually. In practice therefore, there is no difference with respect to measurements of peak power between active and inactive frequency hopping. Accordingly, Siemens VDO proposes the following peak power measurement procedures:

---

24 *Further Notice* at ¶ 160.

1. Determine the occupied BW and the maximum peak power within this BW with the frequency hopping active, the spectrum analyzer in sweep mode with sufficient sweep time and by applying a peak detector and in peak hold mode.
2. Use the spectrum analyzer in zero span mode applying a peak detector to measure the peak power at the frequencies where the maximum peak power occurs and at the highest and lowest frequency. (Note: the readings should be, within a certain measurement tolerance, identical with the measurement in step 1.)
3. If possible, set the pulsed FH SRR carrier frequencies to the three frequencies (highest and lowest frequencies and maximum peak frequency) used in step 2, with the frequency hopping stopped, but with the time-gating (pulse and PRF) on. (Note: the readings should be, within a certain measurement tolerance, identical with the measurement in steps 1 and 2.) With the frequency hopping stopped and the spectrum analyzer in sweep mode the instantaneous occupied BW of a single hop can be determined. The reciprocal of the instantaneous occupied -10 dB BW is the pulse width.
4. If possible, set the pulsed FH SRR carrier frequencies to the three frequencies (highest and lowest frequencies and maximum peak frequency) used in steps 2 and 3, with the frequency hopping stopped and with no time-gating (pulse and PRF off). (Note: here the reading indicates the peak power of the unmodulated carrier, i.e. the total peak EIRP value).
5. All of the readings measured in steps 1 to 3 should be below the peak limit of 0 dBm/50 MHz[25] contained in the UWB rules. The values found in step 4 can be compared to the peak limits measured in steps 1 to 3 by applying the PDCF. The difference in the spectrum analyzer readings should result in the PDCF value.

B. Average Power Measurements

To measure the RMS over the entire occupied BW, the frequency hopping must be active. This conclusion is supported by measurement tests of a prototype of a Siemens VDO pulsed FH SRR recently performed by NTIA, in conjunction with the FCC's Office of Engineering and Technology. The resulting draft NTIA report

---

25/ Alternatively, the readings could be any other scaled value for the used RBW according to 20 log (RBW/50 MHz) between 1 and 50 MHz with the spectrum analyzer's VBW at least as large as the used RBW.

concludes that "the radiated emissions from a pulsed FH radar prototype can be accurately measured in frequency hopping mode." [26]/

With the frequency hopping stopped, the average power (RMS) measurement would only show a single line power spectrum where the sinc-envelope is determined by the pulse width, and the individual single power-lines are separated by the PRF value. This spectrum is typical for a pure pulsed device. One important manner in which the Siemens VDO pulsed FH and the pure pulsed devices differ relates to the pulse width. Pure pulsed devices have a pulse width between 0.1 to 2 ns, whereas the Siemens VDO pulsed FH SRRs have typical pulse widths of 50 ns. Measured in a 1 MHz RBW, the difference in the PDCF is therefore approximately 28 dB (*i.e.,* the peak power over entire BW of the Siemens VDO pulsed FH SRRs must be lower by about 28 dB compared to pure pulsed devices with a 2 ns pulse width and the same PRF in order to achieve similar SLP levels).

Furthermore, if the RMS power were measured with the frequency hopping stopped, the additional power spreading due to the frequency hopping would not be captured by the RMS measurements. Because the occupied bandwidth that results from frequency hopping, B_{FH}, is much greater than the instantaneous occupied bandwidth resulting from pure pulse spreading, B_{pulse}, the RMS measurement over the entire frequency hopping bandwidth B_{FH} would either result in: (1) no RMS reading at all, if not measured within the instantaneous occupied bandwidth B_{pulse}, or (2) a RMS reading that reflects the instantaneous, pure pulse related average

---

[26]/ NTIA, "Measurements of Siemens Pulsed Frequency Hopping Vehicular Radar Prototype," Mar. 20, 2003 at 37.

power. Such average power would, depending on the PRF applied, be either a line spectrum or a PSD, both shaped by a sinc envelop function that is controlled by the pulse width. As noted above, the factor B_{FH} / B_{pulse} produces an additional, frequency hopping-related "duty cycle" that reduces the real PRF by the ratio (B_{FH} / B_{pulse}) within the spectrum analyzer's RBW. With a B_{FH} of 1 GHz and a 50 ns pulse width (*i.e.*, B_{pulse} = 20 MHz), the additional, frequency hopping related duty cycle would be 50 (*i.e.*, 17 dB), reducing a real PRF of 1 MHz to a fictive 20 kHz PRF within the 1 MHz RMS RBW. Thus, the Siemens VDO pulsed FH SRRs can properly be regarded as a very low PRF UWB devices with regard to the 1 MHz RMS RBW and 1 ms integration time as required in the UWB rules in 15.521(d).

Based on the discussion above, it is obvious that the only way to measure the RMS power is with the frequency hopping active. The RMS measurement is also perfectly suited to verify whether the emitted power is equally distributed over the entire occupied bandwidth B_{FH}. If the Siemens VDO devices were required to dwell at a given frequency longer than at other frequencies, the RMS measurement taken at that frequency would tend toward a peak value. By contrast, the RMS measurement scheme proposed by Siemens VDO permits the equal distribution of the transmitted power to be easily verified (see Technical Annex at slides 22 – 24).

In view of the foregoing, Siemens VDO proposes the following RMS power measurement for its pulsed FH systems.

1. The spectrum analyzer's detector is set to RMS (or average, if RMS is not available) mode without any further trace processing like averaging on or peak max. hold, etc.
2. The RBW is set to 1 MHz and the VBW is set to at least 1 MHz.

3. The spectrum analyzer's number of measurement points is set to the maximum.

4. The spectrum analyzer's span can be set up to the maximum limit, which is the number of points multiplied by 1 MHz.

5. The sweep time is set to the number of points (or buckets) multiplied by the averaging time.

6. An averaging time of 1 ms, pursuant to § 15.521(d), of 10 ms,[27] as previously proposed by Siemens VDO, should be used. (Based on several conversations with NTIA and the FCC's OET, it appears that the rationale for the 1 ms averaging time is to prohibit UWB devices from using excessive quiescent periods between bursts of UWB pulse-trains to achieve lower average power readings. As the Siemens VDO pulsed FH SRR is limited by the peak power criterion, a further reduction of the average power would not be needed and would not provide any advantage to the pulsed FH system.)

7. According to the spectrum analyzer manuals, trace processing while in RMS operation mode is not possible. Therefore, post processing of the RMS measurements may be needed if the signal is too spiky.

IV. OTHER ISSUES

A. Wideband Part 15 Transmitters

Siemens VDO supports the Commission's proposal to apply to general Part 15 devices a peak power limit equivalent to that contained in the UWB rules. The Commission is correct that this change would eliminate the bias under Part 15 rules that favor narrowband operations. It would also remove the existing incentive that manufacturers have to modify the design of an otherwise "wideband" device, such that it will qualify as a UWB device and be entitled to the higher UWB power limits.

---

[27] As stated above, the 10 ms RMS integration time period should be used in the 22 to 29 GHz vehicular radar band with the exception of the restricted band from 23.6 to 24 GHz.

The Commission proposed a limit of "20 log (RBW/50) dBm EIRP where RBW is the resolution bandwidth of the measurement instrument in megahertz and where RBW must not be greater than one-tenth of the –10 dB bandwidth of the emission being measured." 28/ As explained below, Siemens VDO believes that the Commission's proposal for a RBW requirement should be modified. 29/

For pure pulsed systems, the spectral power envelop has a sinc shape with line spectra separated by the PRF. Depending on the applied pulse width and the PRF, the "one tenth of the –10 dB bandwidth" rule could result in a situation where only one or two spectral lines fall within the spectrum analyzer's RBW. For example, a 50 ns pulse results in a sinc-envelop with the first zero crossings at +/- 20 MHz and an instantaneous -10 dB bandwidth (*i.e.*, where the line power drops below the -10 dB limit for the *last* time) of 20 MHz. Thus, if the "one tenth of the –10 dB bandwidth" rule were applied, the RBW would be 2 MHz. With a PRF of 2 MHz only one spectral line would fall within the spectrum analyzer's RBW. Based on figure 11, excerpted from an NTIA report on UWB signal characteristics, 30/ it is apparent that the 20 *log rule for* peak power bandwidth conversion is no longer accurate when the PRF is equal to the RBW.

28/ *Further Notice* at ¶ 163.

29/ Siemens VDO proposes to apply the more stringent one-tenth of the -10 dB bandwidth peak measure requirement only for the restricted band. For the rest of the 22 to 29 GHz vehicular radar band, the full -10 dB bandwidth should be allowed for the peak measurement, with the restriction that the total EIRP power has to be reduced by 20 log (50 MHz / instantaneous occupied BW). This limitation is based on a better technical rationale than the use of the one-tenth BW criterion.

30/ *See* NTIA, "The Temporal and Spectral Characteristics of Ultrawideband Signals," Report No. 01-383 (Jan. 2001).

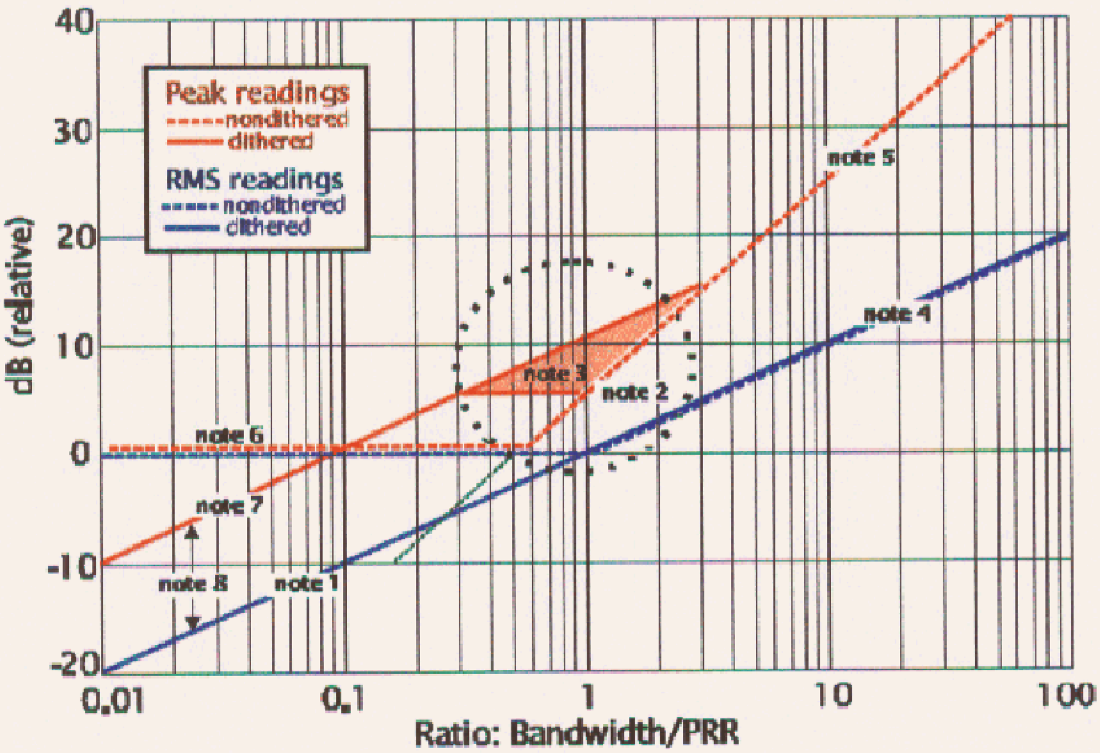
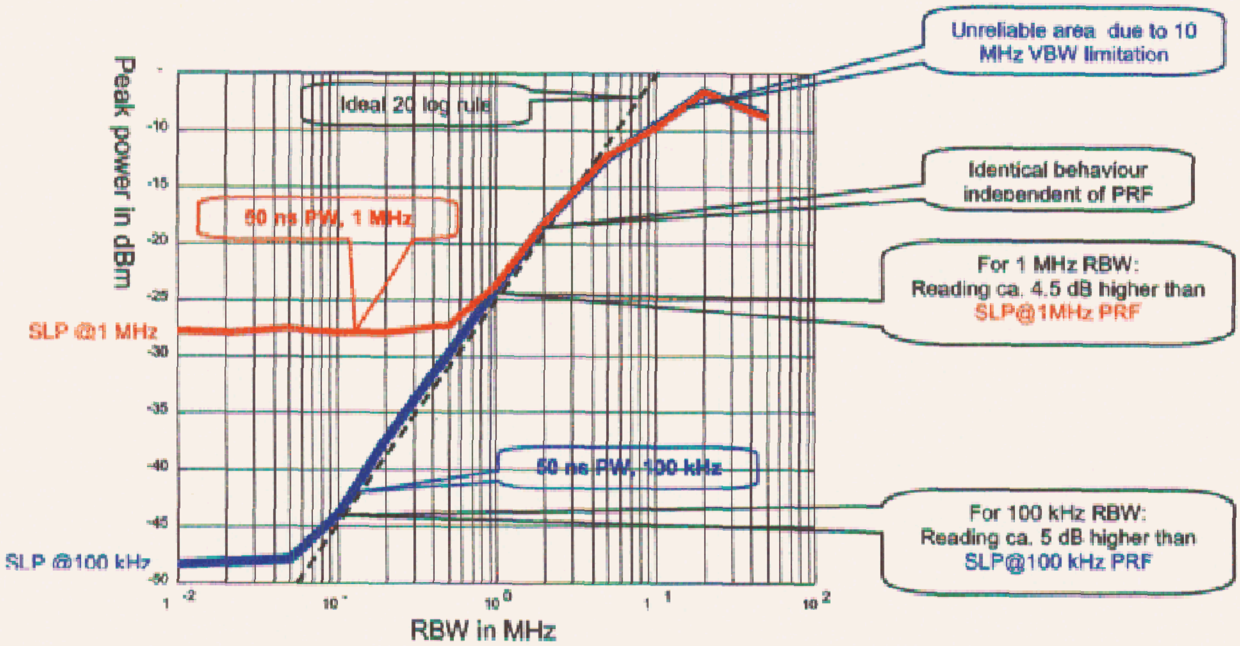


Figure 8.86. Idealized peak and RMS detector values model.

Figure 11: RMS readings vs. RBW/PRF ratio.

In the worst case, the power reading would be 6 dB higher than the actual peak power measured with a higher RBW. Thus, restricting the RBW to only one-tenth of the instantaneous bandwidth would penalize such systems by as much as 6 dB peak power reduction. By using a RBW that is 10 times higher (*i.e.*, the full –10 dB instantaneously occupied BW), this penalty factor will be reduced below 0.5 dB, which is acceptable.

Pulse-modulated carrier (50 ns PW, PRF:1 MHz vs. 100 kHz): SLP transient region



Remark:
Depending on the spectrum analyzers RBW filter characteristic the reading indicates higher values (up to 6 dB possible for box-shaped RBW filter) in the transient region where PRF equals RBW. To avoid this error, RBW must be (much) greater than the PRF.

Figure 12: Peak readings for different RBWs and a PRF of 1 MHz and 100 kHz.

As an alternative to the Commission's proposal, Siemens VDO proposes that, for measuring the peak power of conventional Part 15 devices, the Commission use the instantaneously occupied -10 dB bandwidth. Alternatively, a fixed RBW of 1 MHz for peak power measurements could be used, but with a limit of -28 dBm/MHz, (*i.e.*, 6 dB higher than the 20 log rule bandwidth conversion value of -34 dBm/MHz), thereby compensating for the 6 dB increase in peak power readings. If the PRF stays (far) below the 1 MHz RBW, this compensation factor can be gradually reduced according to the mathematical relationship.

B. Elimination of the UWB Definition

For the reasons stated above in section II.A, Siemens VDO supports the Commission's proposal to eliminate the minimum bandwidth requirement currently contained in Section 15.503(d) of the Commission's rules. In response to the Commission's additional questions on this matter, Siemens VDO does not believe that any other spectral power density limit based on a bandwidth narrower (or wider) than 1 MHz is necessary. System theory dictates that only the *ratio* of PRF to RBW is important, not the absolute values (*see also* Figure 11). Siemens VDO further suggests that the same procedures and limits contained in the UWB rules be applied to conventional Part 15 devices (*i.e.*, no "one-tenth BW" or other biased limitation should be imposed).

CONCLUSION

For the foregoing reasons, Siemens VDO urges the Commission to adopt the rule changes proposed in the *Further Notice* and as suggested herein that will permit Siemens VDO's pulsed FH vehicular radar devices to operate as UWB devices.

Respectfully submitted,

SIEMENS VDO AUTOMOTIVE AG

Ari Q. Fitzgerald /DLM

Dr.Ing. Martin Kunert

SIEMENS VDO AUTOMOTIVE AG
Osterhofener Straße 19
93055 Regensburg
Germany

Ari Q. Fitzgerald
David L. Martin

HOGAN & HARTSON L.L.P.
555 13th Street, N.W.
Washington, DC 20004
(202) 637-5600

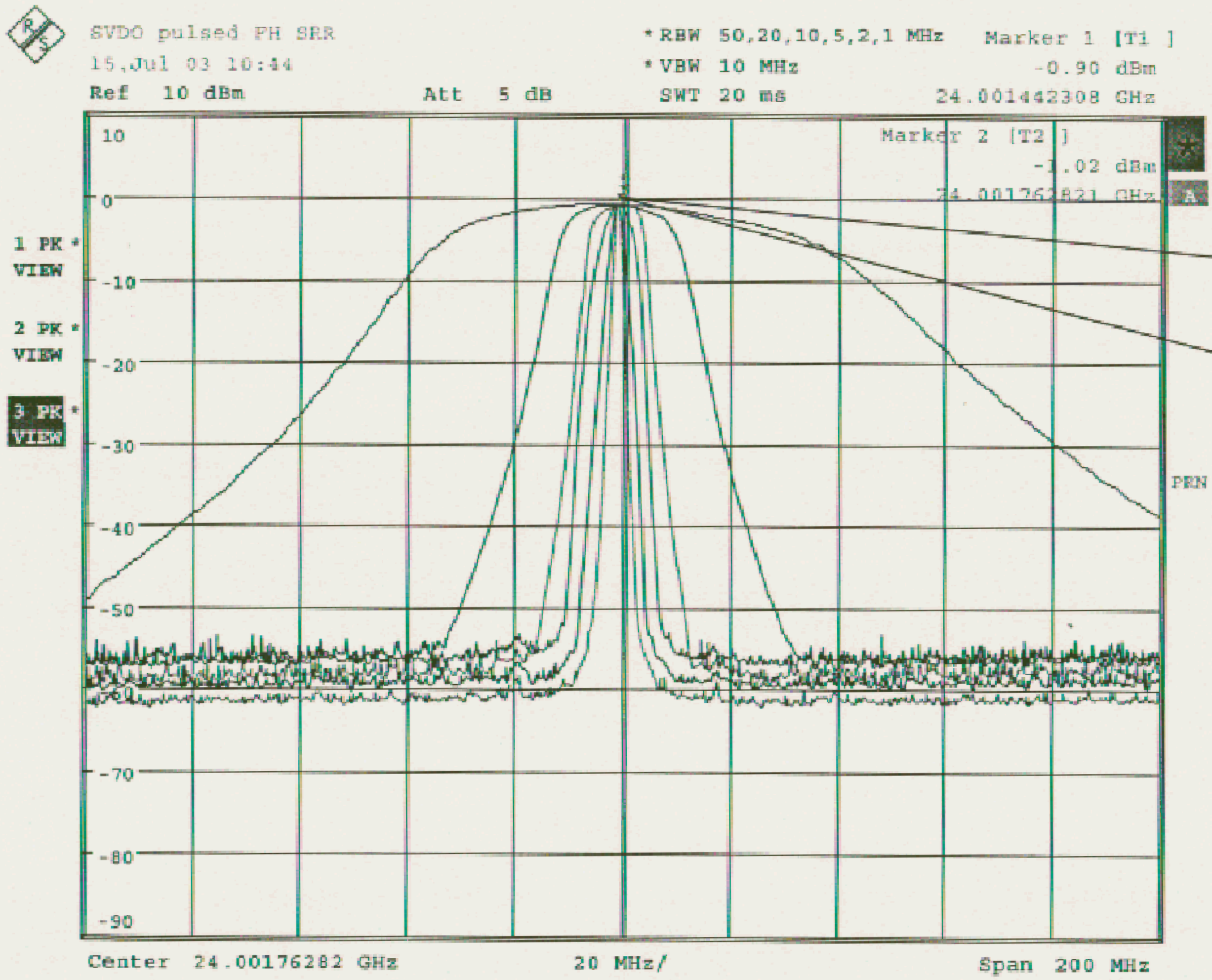
Dated: July 21, 2003

ATTACHMENT A

TECHNICAL ANNEX

to the Comments of Siemens VDO
filed in ET Docket 98-153
July 21, 2003

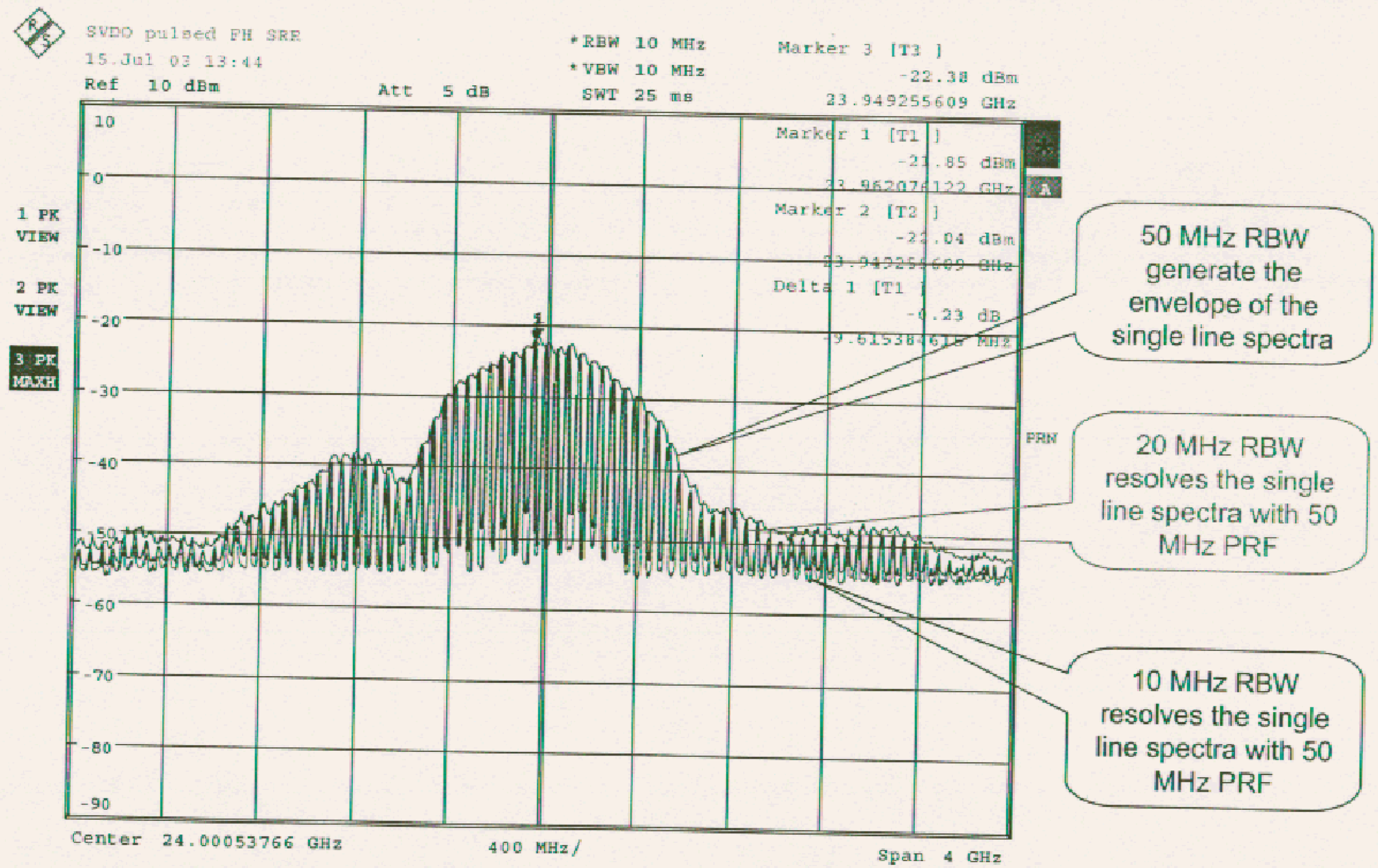
Unmodulated carrier EIRP is ca. -1 dBm for RBW from 1 to 50 MHz



The peak power is ca. – 1dBm for all RBWs As the unmodulated carrier is very narrowband, the spectrum analyzer reproduces its own RBW filter characteristic

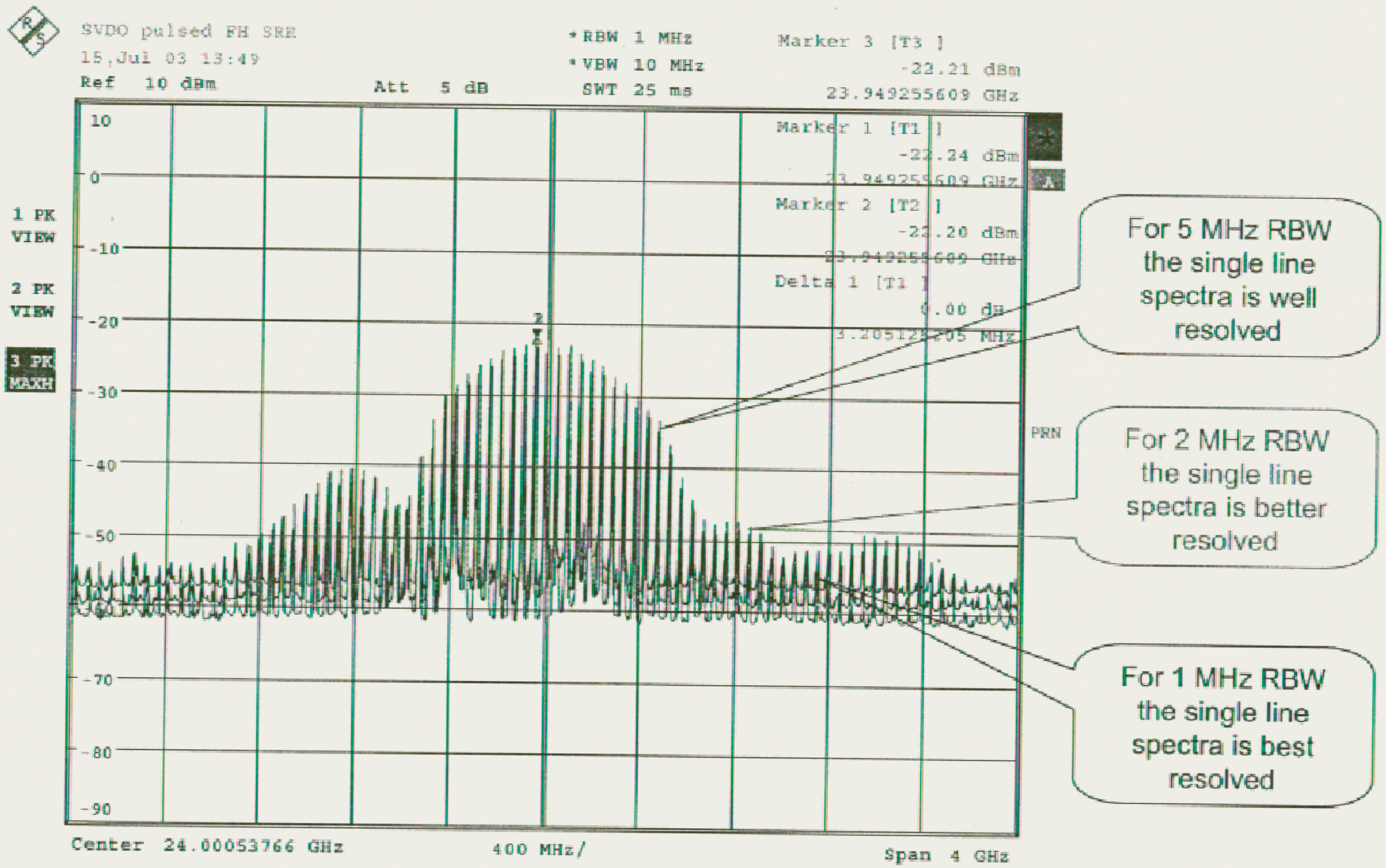
Comment A: unmodulated carrier EIRP in 50,20,10,5,2,1 MHz RBW
VBW is 10 MHz, free space correction included in readings
Date: 15.JUL.2003 10:44:36

Pulse-modulated (1.6 ns PW, 50MHz PRF) carrier in 50,20 and 10 MHz RBW



Comment A: pure pulse carrier 1.6ns PW, 50 MHz PRF
MaxH, VBW is 10 MHz, RBW 50,20,10 MHz
Date: 15.JUL.2003 13:44:46

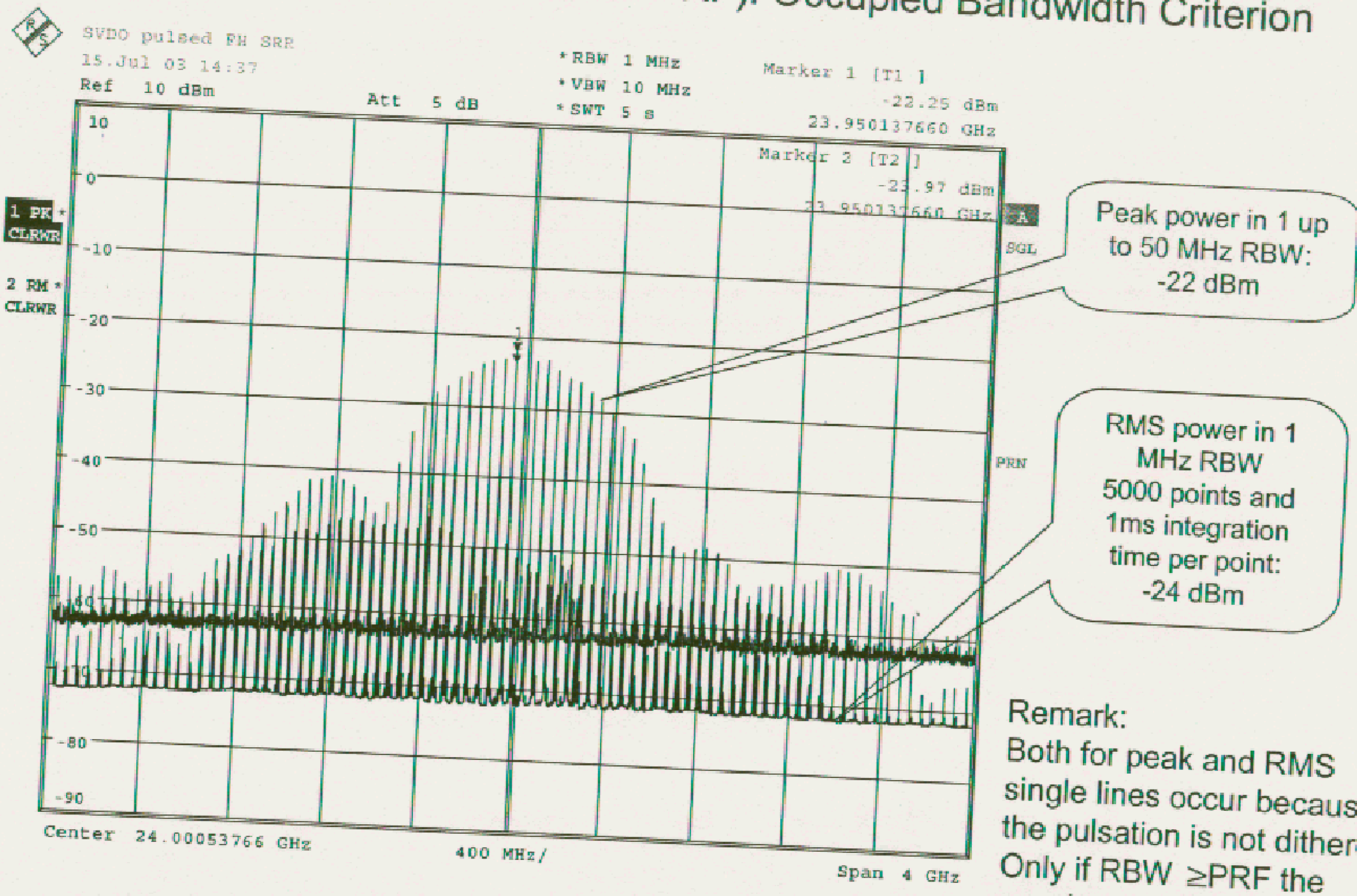
Pulse-modulated (1.6 ns PW, 50MHz PRF) carrier in 5,2 and 1 MHz RBW



Comment A: pure pulse carrier 1.6ns PW, 50 MHz PRF
MaxH, VBW is 10 MHz, RBW 5,2,1 MHz
Date: 15.JUL.2003 13:49:55

Remark:
The absolute power levels of the single lines don't changes if the RBW is reduced, because only one line falls within the RBW !

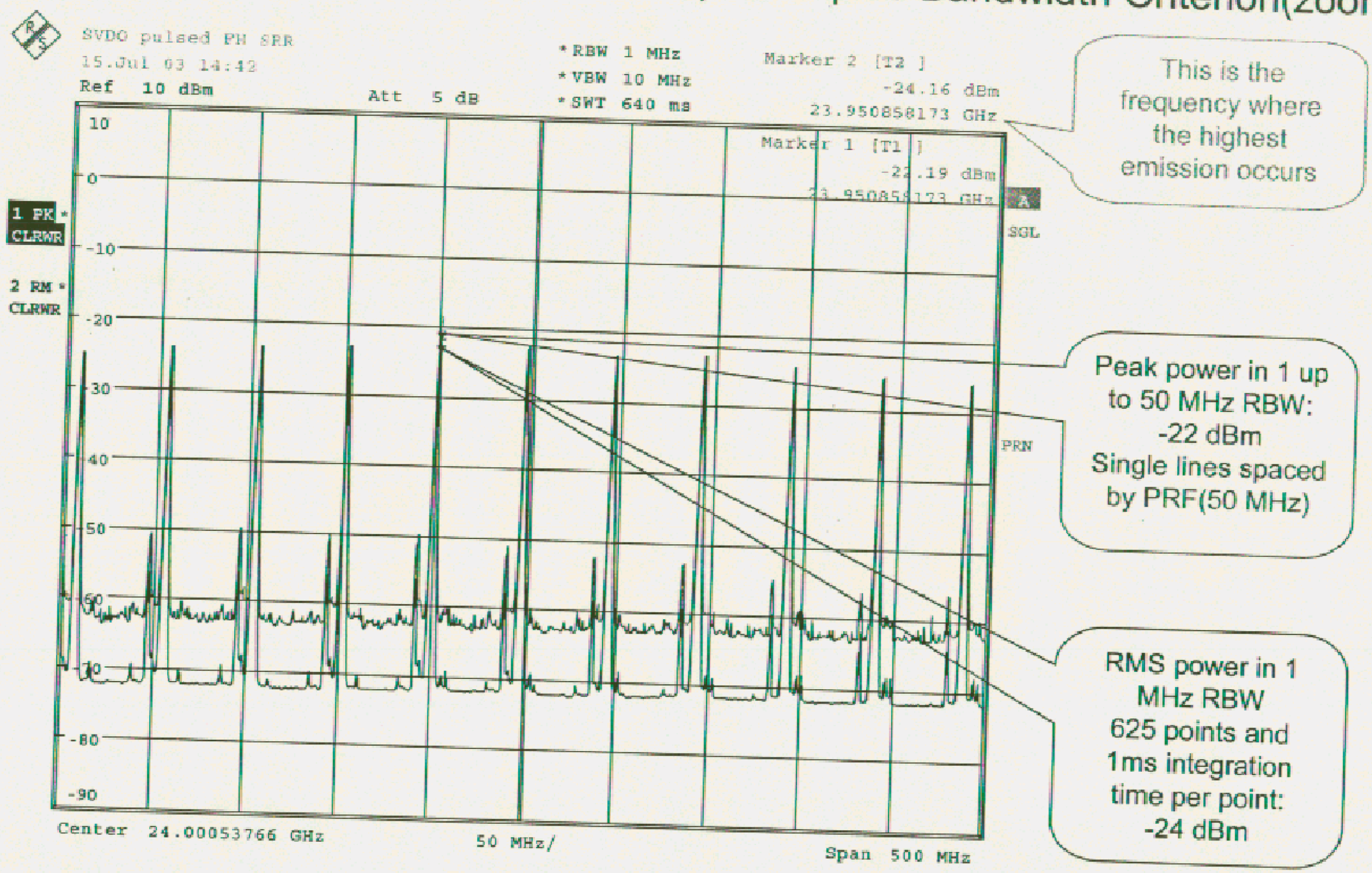
Pulse-modulated (1.6 ns PW, 50MHz PRF): Occupied Bandwidth Criterion



Comment A: pure pulse carrier 1.6ns PW, 50 MHz PRF
MaxH, VBW is 10 MHz, RBW 1MHz: peak, RMS 5000 points 1ms
Date: 15.JUL.2003 14:37:24

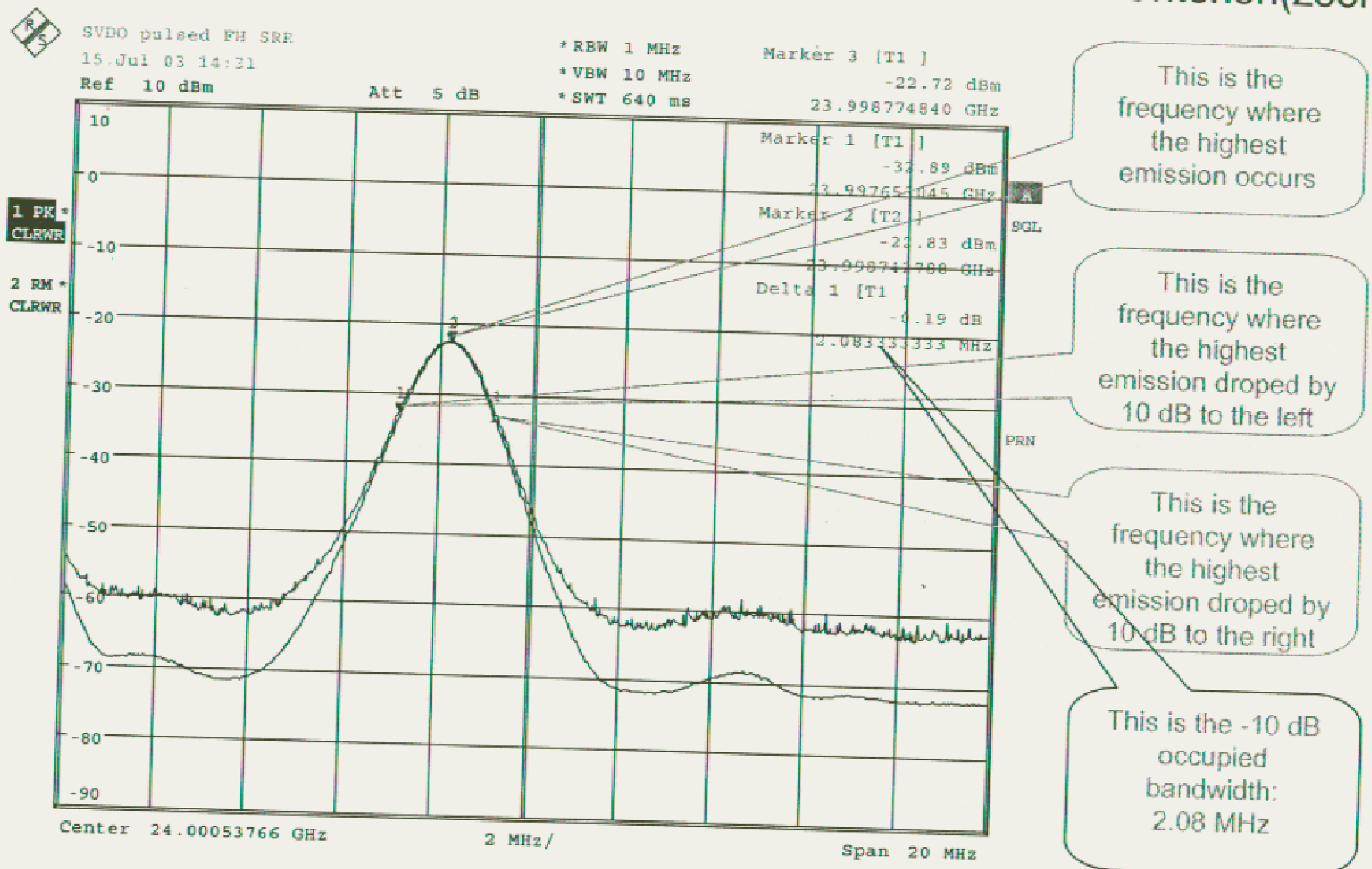
Remark:
Both for peak and RMS single lines occur because the pulsation is not dithered. Only if RBW ≥PRF the envelope of the discrete spectrum get visible

Pulse-modulated (1.6 ns PW, 50MHz PRF): Occupied Bandwidth Criterion(zoomed)



Comment A: pure pulse carrier 1.6ns PW, 50 MHz PRF
MaxH, VBW is 10 MHz, RBW 1MHz: peak, RMS 625 points 1ms
Date: 15.JUL.2003 14:43:04

Pulse-modulated (1.6 ns PW, 50MHz PRF): Occupied Bandwidth Criterion(zoomed)



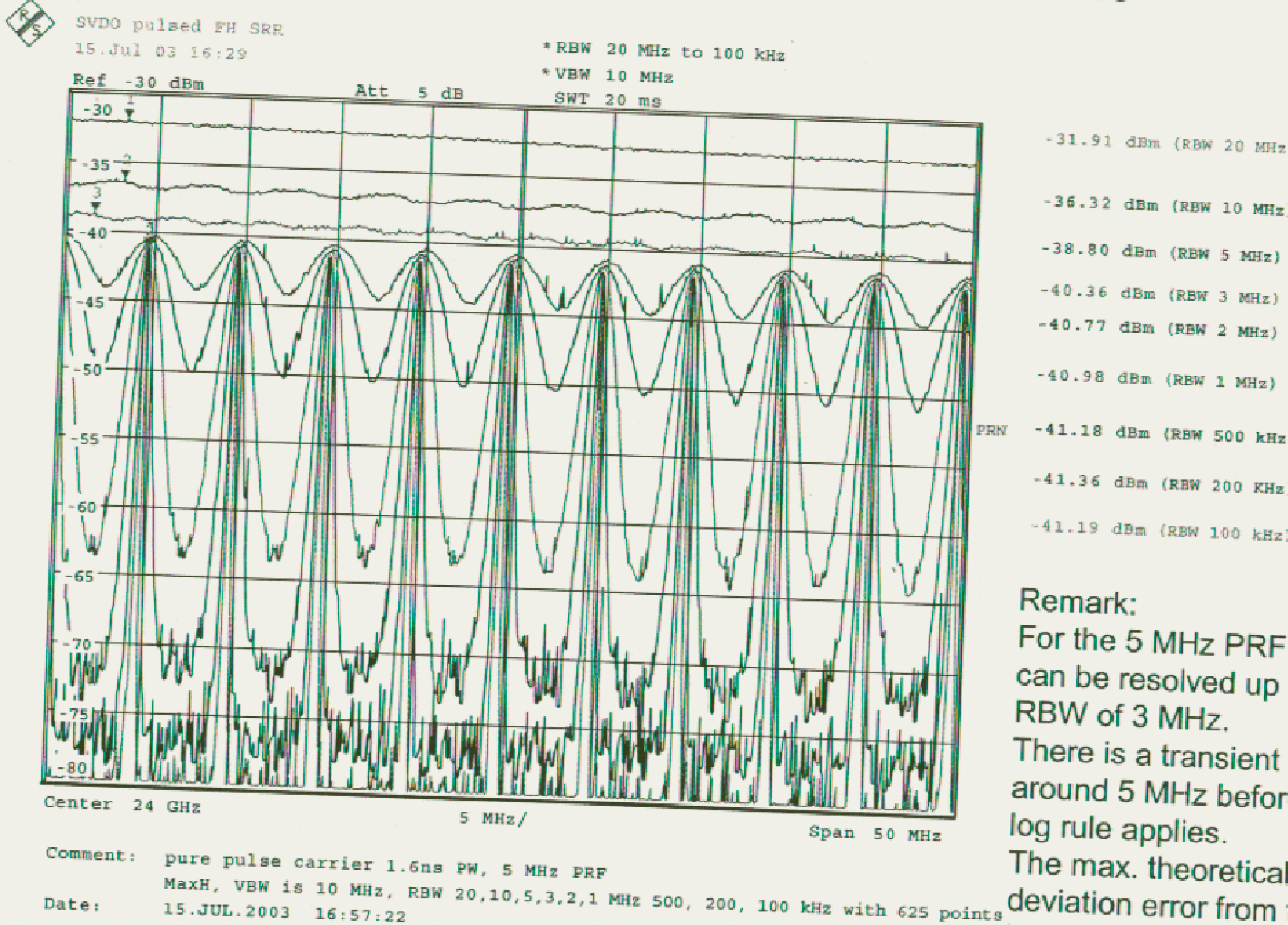
Comment A: pure pulse carrier 1.6ns PW, 50 MHz PRF ¶
MaxH, VBW is 10 MHz, RBW 1MHz: peak, RMS 625 points 1ms

Date: 15.JUL.2003 14:31:11

Remark:

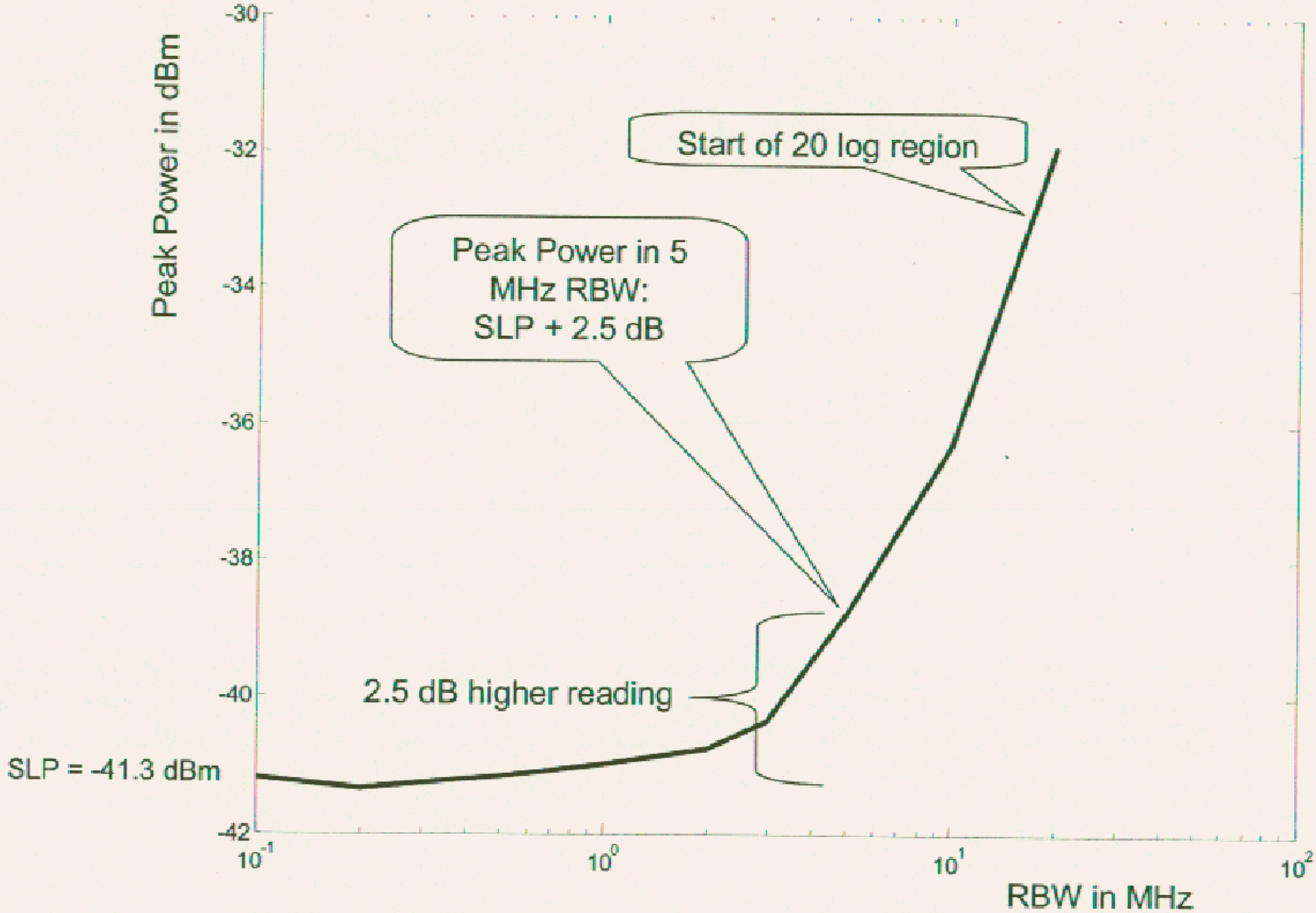
Both for peak and RMS measurements of undithered pulsed signals with RBW < PRF a SLP (single line power) spectrum occurs. For these cases the -10 dB bandwidth criterion has to be amended (e.g. envelope)

Pulse-modulated (1.6 ns PW, 5MHz PRF): SLP in different RBWs

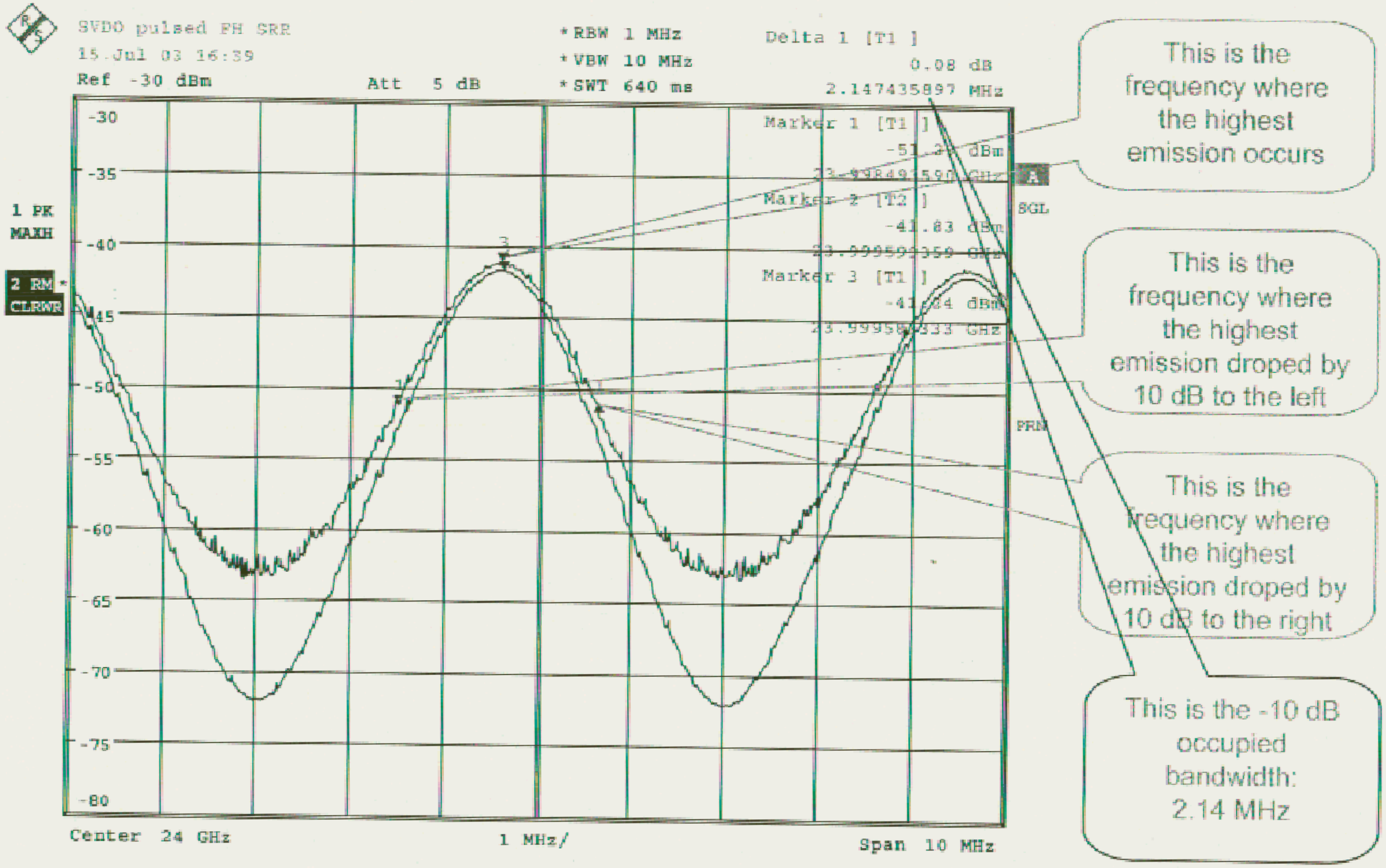


Remark:
For the 5 MHz PRF the SLP can be resolved up to a RBW of 3 MHz.
There is a transient region around 5 MHz before the 20 log rule applies.
The max. theoretical deviation error from the 20 log rule is 6 dB !

Pulse-modulated carrier (1.6 ns PW, 5MHz PRF) - SLP transient region



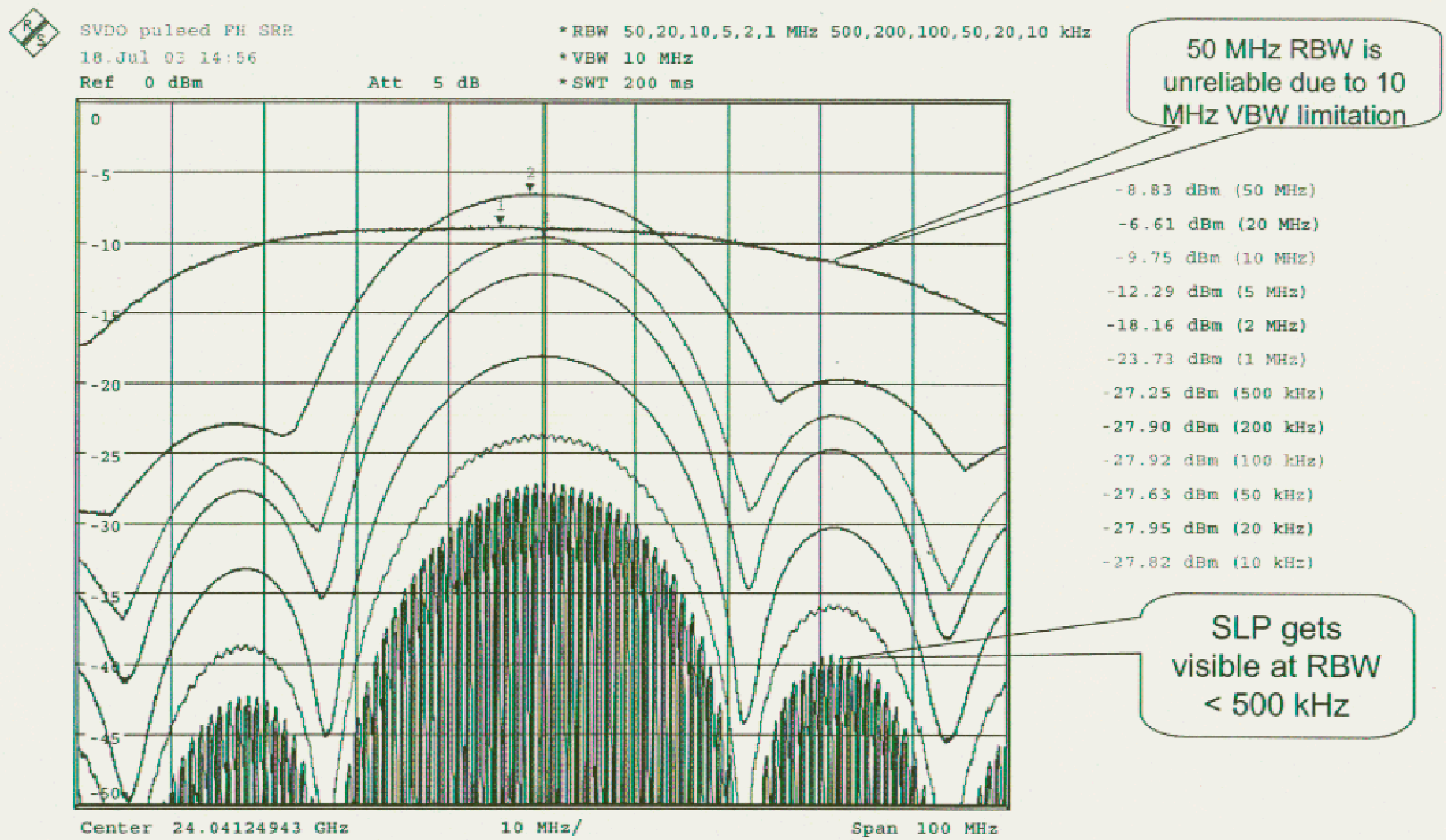
Pulse-modulated (1.6 ns PW, 5MHz PRF): Occupied Bandwidth Criterion(zoomed)



Comment A: pure pulse carrier 1.6ns PW, 5 MHz PRF
MaxH, VBW is 10 MHz, RBW 1 MHz, Peak and RMS 625 points 1ms
Date: 15.JUL.2003 16:39:37

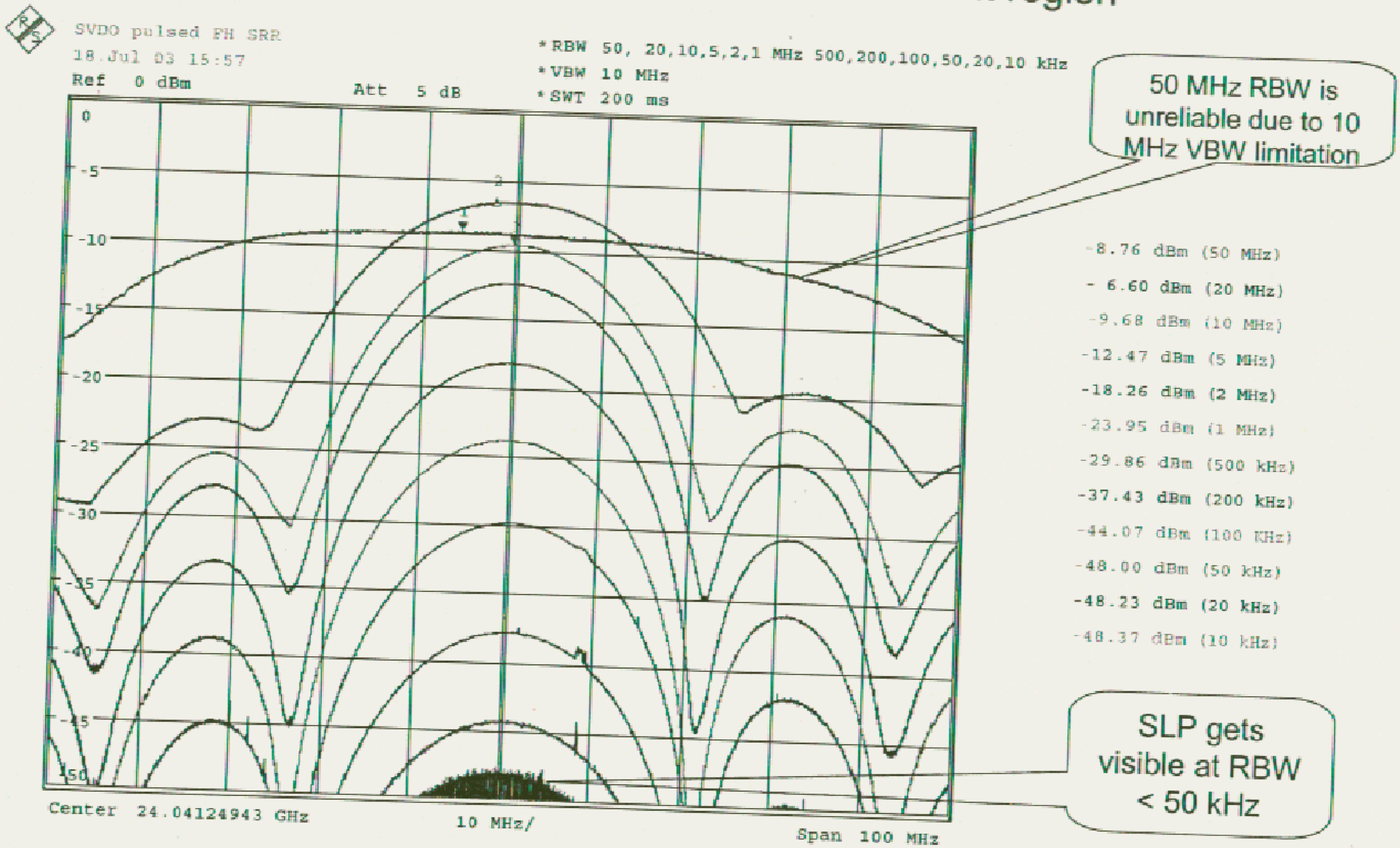
Remark:
Both for peak and RMS measurements of undithered pulsed signals with RBW < PRF a SLP (single line power) spectrum occurs. For these cases the -10 dB bandwidth criterion has to be amended (e.g. envelope)

Pulse-modulated (50 ns PW, 1MHz PRF): SLP transient region



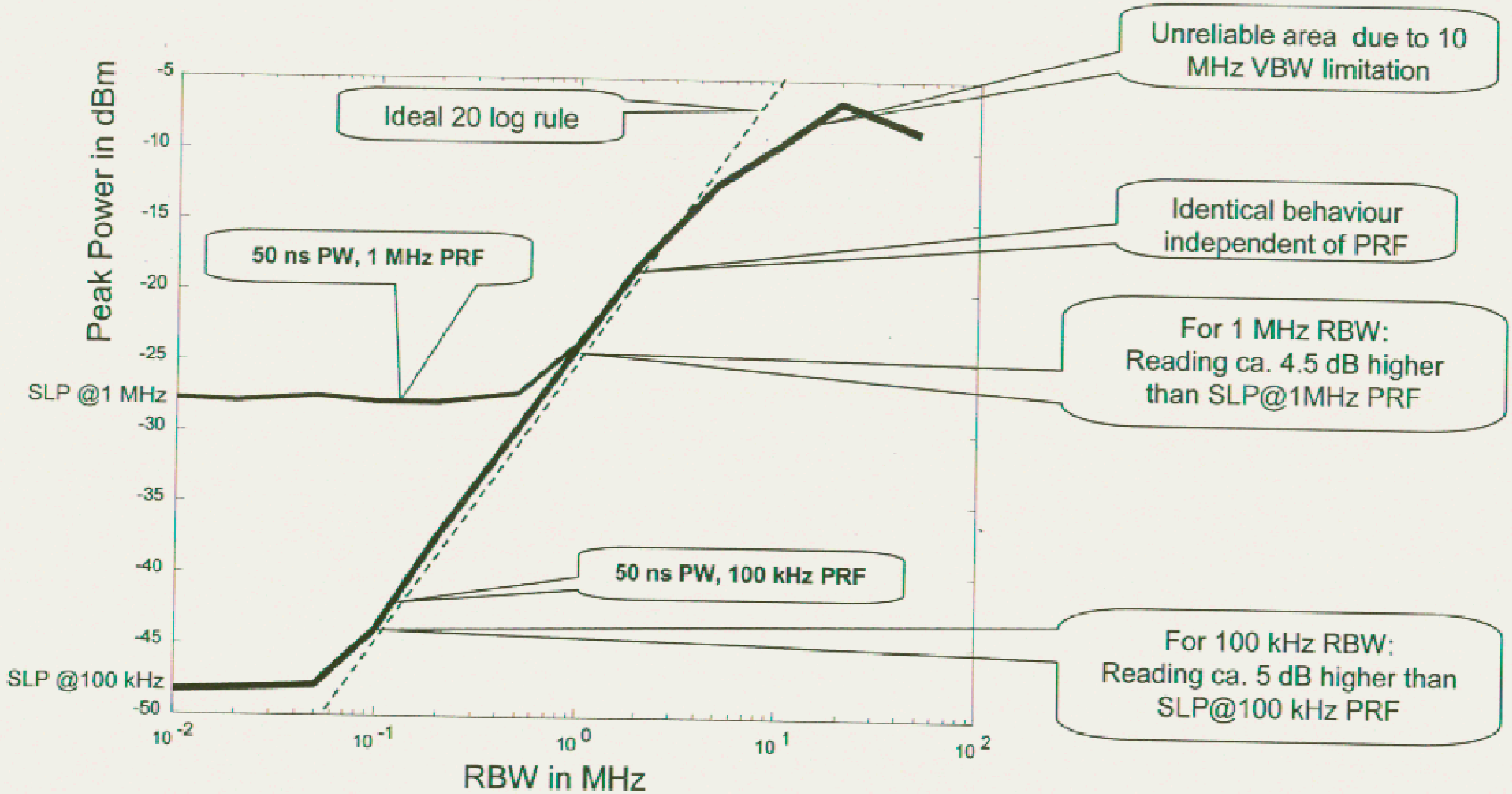
Comment A: pure pulse carrier 50ns PW, 1 MHz PRF
MaxH, VBW 10 MHz 5001points RBW: 50,20,10,5,2,1 MHz 500,200,100,50,20,10 kHz
Date: 18.JUL.2003 14:56:13

Pulse-modulated (50 ns PW, 100 kHz PRF): SLP transient region



Comment A: pure pulse carrier 50ns PW, 100 kHz PRF
MaxH, VBW 10 MHz 5001points RBW: 50,20,10,5,2,1 MHz 500,200,100,50,20,10 kHz
Date: 18.JUL.2003 15:57:05

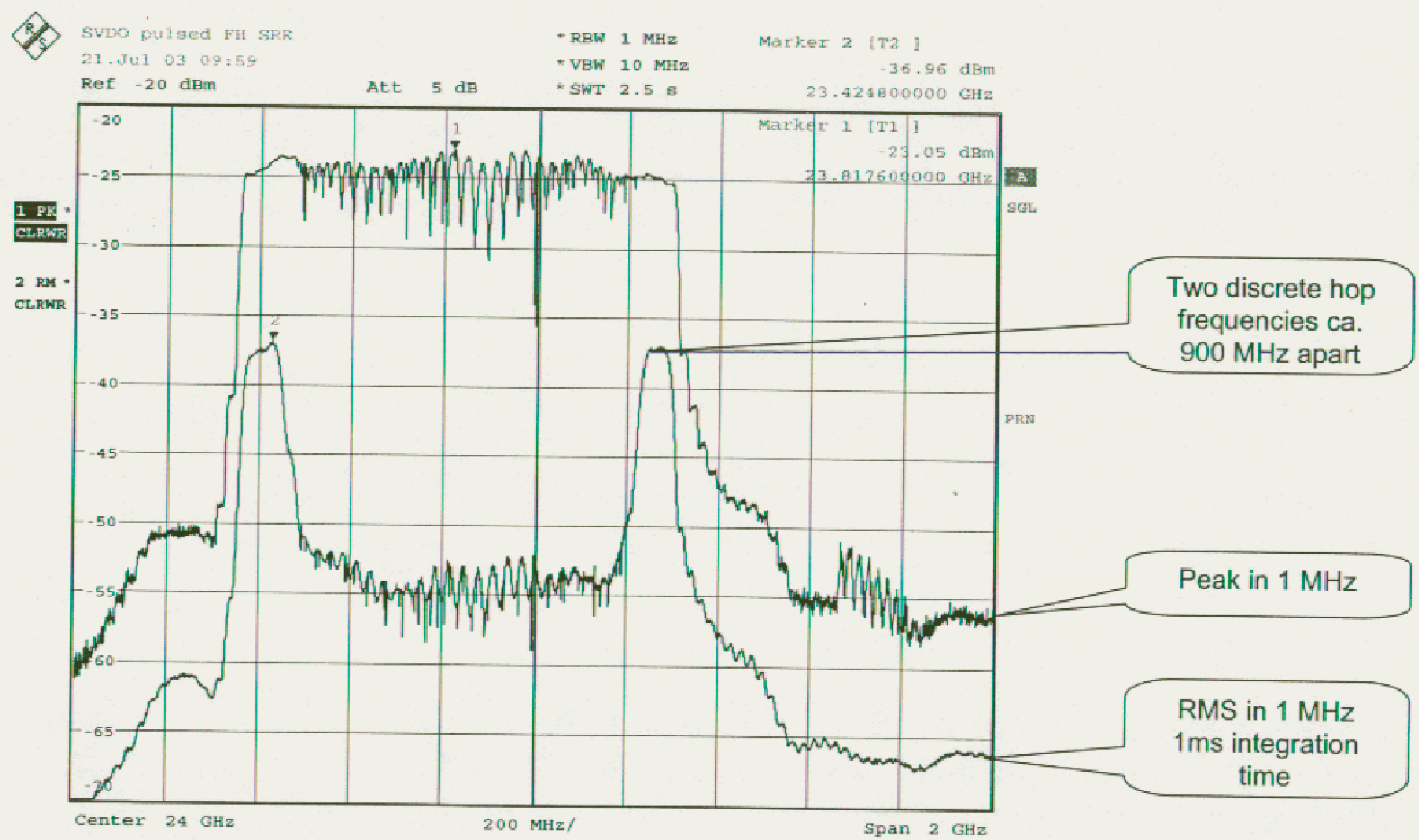
Pulse-modulated carrier (50 ns PW, PRF:1 MHz vs. 100 kHz): SLP transient region



Remark:

Depending on the spectrum analyzers RBW filter characteristic the reading indicates higher values (up to 6 dB possible for box-shaped RBW filter) in the transient region where PRF equals RBW. To avoid this error, RBW must be (much) greater than the PRF.

Pulse-modulated carrier (50 ns PW, 1 MHz PRF): Dual tone FH



Comment A: Dual tone pulsed FH 50ns PW, 1MHz PRF,40 µs tone PRF, 50% E
VBW 10MHz RBW 1MHz 2501points 2.5s ST, singles
Date: 21.JUL.2003 09:59:19